A Novel Optical Module Packaging Teaching Course

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ABSTRACT: *Optical transceiver module which includes the transmitter and receiver plays a key role in the optical communication network. The data transfer speed will be dominated by the transceiver module. This paper proposed a novel transceiver packaging training course for the college and graduate students. Through the integration of the theory introduction and the experiment operation, the key technology of the module packaging can be taught to the students. Generally, an optical transceiver includes a top-cover, box, component submount, invar plate, invar substrate, U-channel, fiber, ferrule, laser diode, and thermal electric cooler (TEC). The purpose of this course is to show and teach how to assemble all the above components inside the box quickly, precisely, and stable with the various packaging technology. A novel structure is introduced here to separate the packaging technology into two parts so the course training can be clearer and easier. One is the mounting of components because every component used in the module has to be precisely positioned and fixed at the right place to ensure the module performance. Positioning control and image inspection technology is key technology in this part. And another part would be the light alignment between the laser diode and the fiber. The light coupling efficiency decides the final performance of the module. Various alignment structure and method will be introduced here. All experiments will accompany with a brief theory and application instruction in the classes, so the students can have a basic understanding to the purpose, theory basics, and application field of the experiments.*

1 INTRODUCTION

Since 1995, the Internet has been developed. It offers various services in the Internet; such as, electronic commerce, video conference, and data transmission. Therefore, the wideband demand has to be provided because the service in the Internet. The worldwide demand for bit rate capacity seems to double every three years. Only optical communication system can satisfy the transport of such information capacity requirement. In optical communication systems, the data transfer speed is dominated by the transceiver module, which includes a transmitter and a receiver. The packaging of the transceiver is a combination of many different domain-specified technologies like optics, mechanics, image-detection, positioning, and etc. A good transceiver means that packaging problems encountered among these technologies can be solved appropriately. This is not an easy job for a normal engineer who didn't have related knowledge about this packaging technology.

For the purpose to provide enough engineer resource to the related industry in the future, training must be done before they graduate from the school, both college and graduate students. In our school, National Sun-Yat-Sen University, the courses related to the optical communication in both college and graduate education are almost theoretical. And most of these courses mentioned lots of optical technologies, other important topics like positioning and fixing in the micro space and relatively high accuracy, have not been discussed extensively in the present courses. In order to establish related optical packaging knowledge to the students, an integrated course which combine the theory and hands-on experiment is necessary. The main concept of the course is design for learned by done. The various packaging technology on optical module packaging application can be taught to the students. In addition to, the relative knowledge and skills can be taught to the students, too; for example, motion control, image inspection, machining, soldering, laser welding, grinding, light coupling etc. The knowledge and skills are not only used around optical transceiver module packaging but also can be used in some other packaging

application. The optical transceiver module packaging process can be distinguished orderly into several processes, which each process has planned into an independent topic.

The purpose of this course is to plan a novel integrated electro-optical module packaging experiment; besides, regular theoretical classes. In this course, electro-optical packaging technology can be learned by using observation, discussion and hands-on operation.

2 SCHEME AND PACKAGING PROCEDURE

Generally, the scheme of an optical transceiver is shown in Fig. 1, and includes as below:

- Top cover, box
- Submount, invar plate, invar substrate, U-channel
- Fiber and ferrule
- Laser diode
- Thermal electric cooler(TEC)

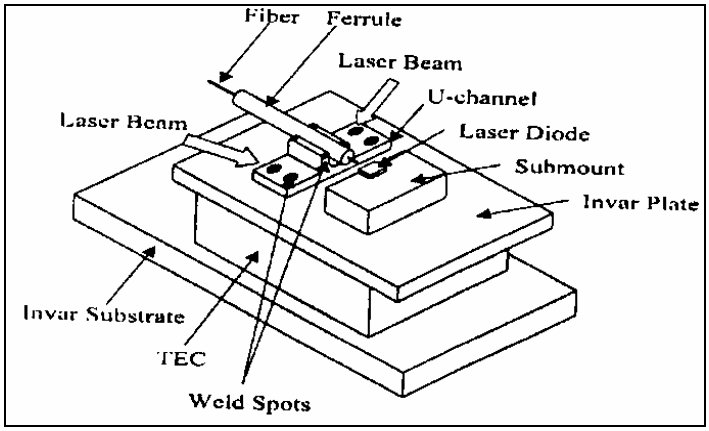

Fig 1 Scheme of transceiver module

Transceiver module packaging means to assemble all of the above components inside the box. Besides, it also has to match mechanical accuracy and optical communication specification to ensure the transfer performance. Consequently, the packaging can be divided into two main parts: 2.1 the mounting of the components and 2.2 light coupling between the laser diode and the fiber.

2.1 The mounting of the components

The main purpose of mounting is to place the components in proper order, then fix the components in the box by various attaching method. The optical transceiver module is constructed by following sequence: First, it has to attach the thermal electric cooler (TEC) and invar substrate in the box. Secondly, the submount, photo diode submount, and U-channel are attached to the invar plate. At the last, the invar plate has to fix on the TEC.

The action of the components packaging can be separated into several parts in more detail:

- **Pick up the components**

  The components are grabbed and moved by using the proper clips, then place the components to the right place.

- **Positioning**

  In order to match the desired position accuracy; the clips, substrate, and components are moved and sensed by motion stage and image inspection system, respectively. Or, use passive alignment method; such as, V-groove, ridge, and mark etc.

- **Fixing**

  In the high speed of optical transceiver module, the attaching method can be varied by the material of each component. Generally, the common methods are soldering or laser welding.

2.2 Light coupling between the laser diode and the fiber

After mounting the most parts of components in the box, the next procedure is the light coupling between the laser diode and the fiber. The laser diode and the fiber have to align precisely in order to

obtain the optimal coupling efficiency and guarantee the optical signal transmission efficiency. In this procedure, the light coupling technique is more difficult than the positioning of the components because the slight shift between the laser diode and the fiber can decrease coupling efficiency seriously.

According to the coupling scheme, the Light coupling can be divided into several types:

- **Cleaved fiber coupling**

  Search the highest coupling efficiency by utilizing cleaved endface of fiber, and fix the fiber on the assembly.

- **Lensed fiber coupling**

  The fiber endface has to be processed before coupling by utilizing etching, grinding, or laser trimming to obtain the microlens on the fiber endface. Therefore, the various fiber endface can be fabricated for coupling between the laser diode and the fiber.

- **Lens systems coupling**

  Place a set of lens system between the laser diode and the fiber; in like manner, the light can be focused into the fiber.

The coupling efficiency has to be searched to acquire the optimal efficiency, no matter what kind of coupling schemes. The coupling method can be divided into two parts, active and passive method:

- **Active coupling method**

  The motion stage equipped with power meter is used to search the highest coupling efficiency. Afterwards, the fiber can be fixed on the substrate. This method can obtains relatively high coupling efficiency but spends more cost and coupling time.

- **Passive coupling method**

  The substrate has to be processed before mounting in order to attaching the fiber on the right position which by using V-groove, ridges, and marks. The coupling efficiency is relatively low compare with the active method, but it spends lower cost and less time for packaging.

3 COURSE PLANNING

In generally, for each topic of classes has theory introduction before experiment classes which the object of the experiment, basic knowledge, and application can be taught to the students. Then arrange several classes for experiment to accomplish the packaging technology. The topic is sorted into six parts. The first part is the introduction of entire packaging technology then the rest of the parts can be divided into five parts shown in Fig. 2.

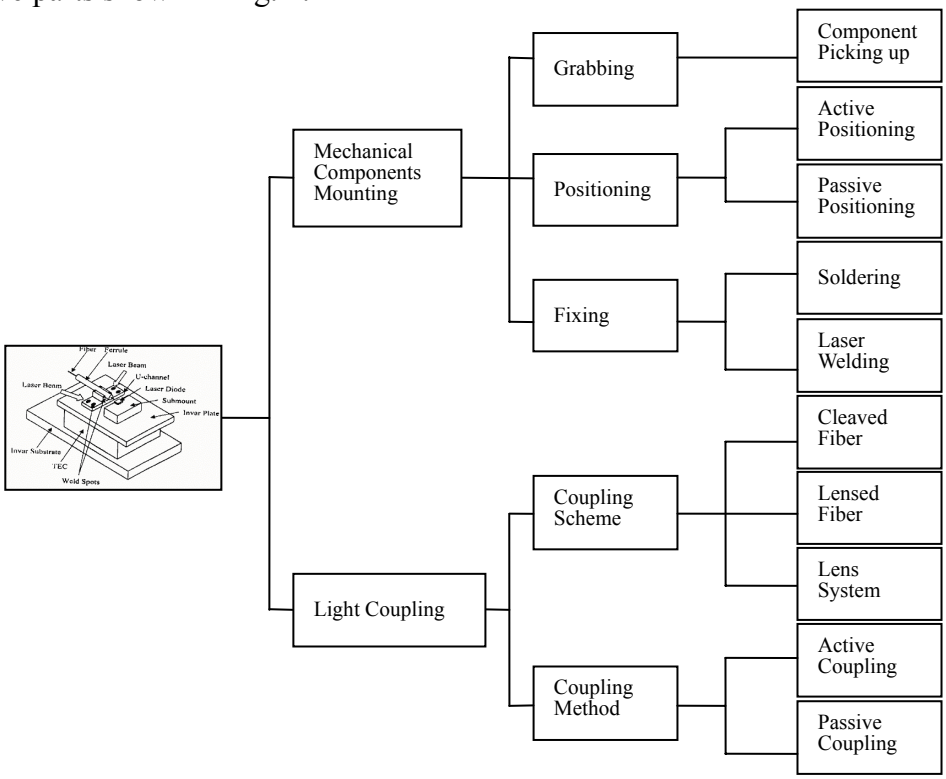

Fig 2 Structure of the course

3.1 Electro-optical components packaging technology introduction

Contents:

The theories, hardware schemes, and practical applications are included in the classes which focus on transceiver module.

Experiment One: Large-sized model fabrication of the transceiver

Through the fabrication of large-sized transceiver module, the common knowledge of structure in the transceiver can be taught to the students, which components of model are made by styrofoam, wood, and any other materials can be easy manufactured.

3.2 Components picking up\grabbing technique

Contents:

Each component can be varied in, material, size, and shape; therefore, when the components are grabbed by the clips which contact point\area between the components and the clips can be varied, too. Then the damage on the components can be avoided. The grabbing techniques and the requests are introduced in the classes.

Experiment Two: Clips understanding

The experiment devices are used in the electro-optical institute. Various grabbing applications on the fiber and the laser diode are introduced to the students.

3.3 Components positioning alignment technique

Contents:

- The various active and passive alignment method are introduced for move the components to the desire position.
- A framework of automatic control systems are introduced
- Image acquisition, measurement technique

Experiment Three: Image processing experiment

The edge and geometric position of the fiber and every other geometric position of components is analyzed on the image by using the image inspection programming.

Experiment Four: Active positioning alignment

Combine the grabbing, the image, and the motion control in the active positioning alignment method in order to place the components to the desire position.

Experiment Five: Passive positioning alignment

The large-sized of V-groove, ridge, and mark has to be fabricated beforehand. The students can pick up each element with clip and then use passive alignment method assists with CCD accurately.

3.4 Components packaging technique

Contents:

Various packaging technique introduction; such as, soldering and laser welding.

Experiment Six: Soldering experiment

A fiber is fixed in the ferrule by soldering.

3.5 Coupling schemes

Contents:

Different coupling schemes, coupling theory, and techniques are introduced in the classes. For example: cleaved fiber coupling, lensed fiber coupling, and lens system coupling.

Experiment Seven: Bare fiber polishing experiment

The fiber endface fabrication is manufactured with fiber polishing machine. And the assigned endface of fiber can be fabricated by hands-on operation.

3.6 Coupling searching technique

Contents:

Principle of coupling searching method

Experiment Eight: Active coupling alignment experiment

The highest coupling efficiency can be varied by utilizing different coupling principle.

4 CONCLUSION

Novel Optical Module Packaging Teaching Course has introduced in this paper. The course has divided into two main parts and then separated into five parts in more detail in order to make the structure of the course orderly and clearly for the learner. The packaging technology has introduced by using the structural course which focus on Optical Module Packaging. Therefore, in one hand, the course of packaging technology can be taught to the students easily; on the other hand, the students can learn and absorb the knowledge of the course efficiently. All of the students in this course can be divided into several groups; then each group of the students can take any individual topic of the course for the first step without confusing. Through this learning process, students can obtain many key technologies about optical packaging. And with this special skill, the opportunity for them to apply a related job will increase. Meanwhile, industry can recruit more engineers to help them improve the performance of the optical module in the future.

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